Results with Revised Microwave Forward Model

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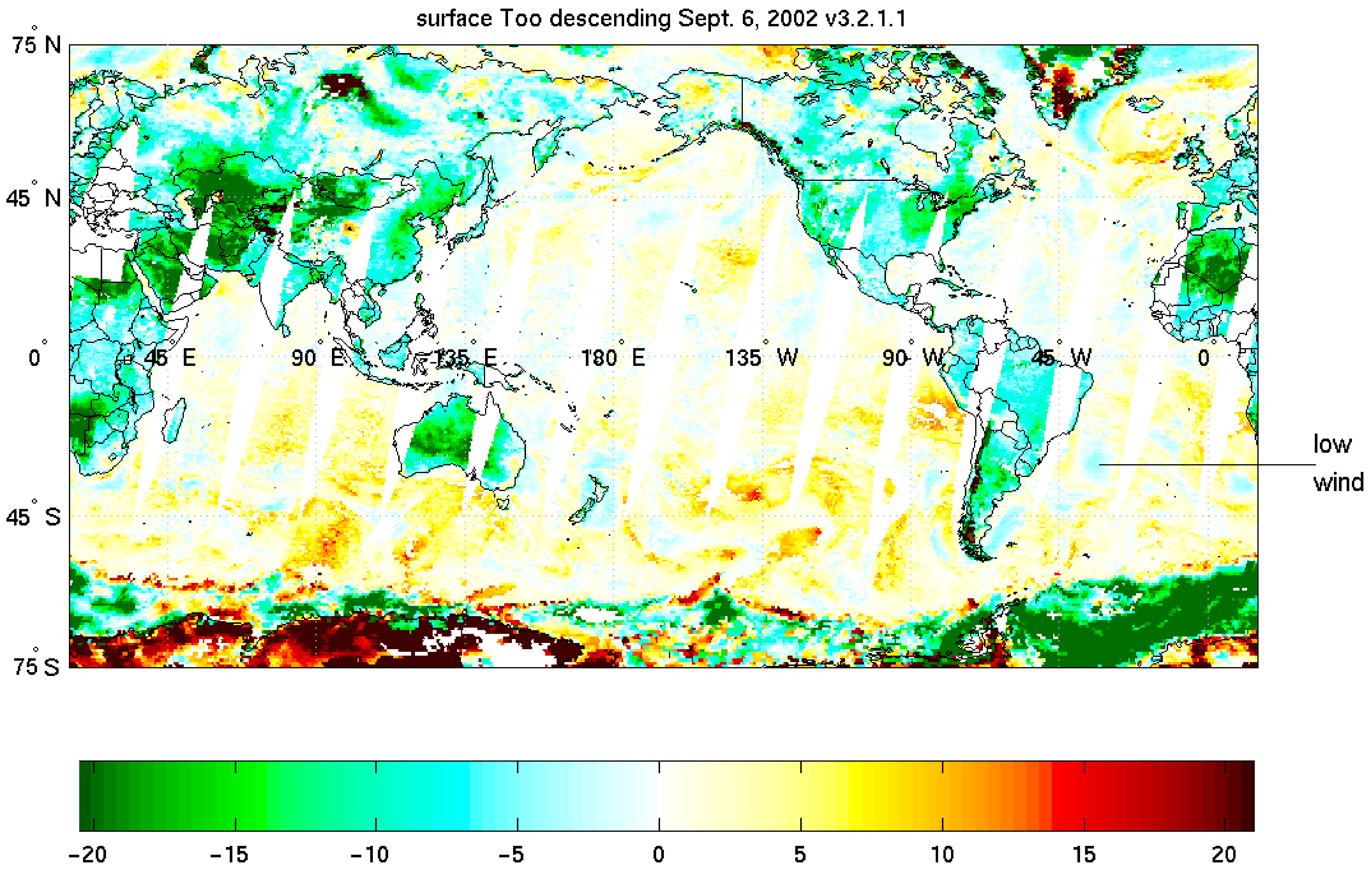
Ocean-surface Roughness and Tuning

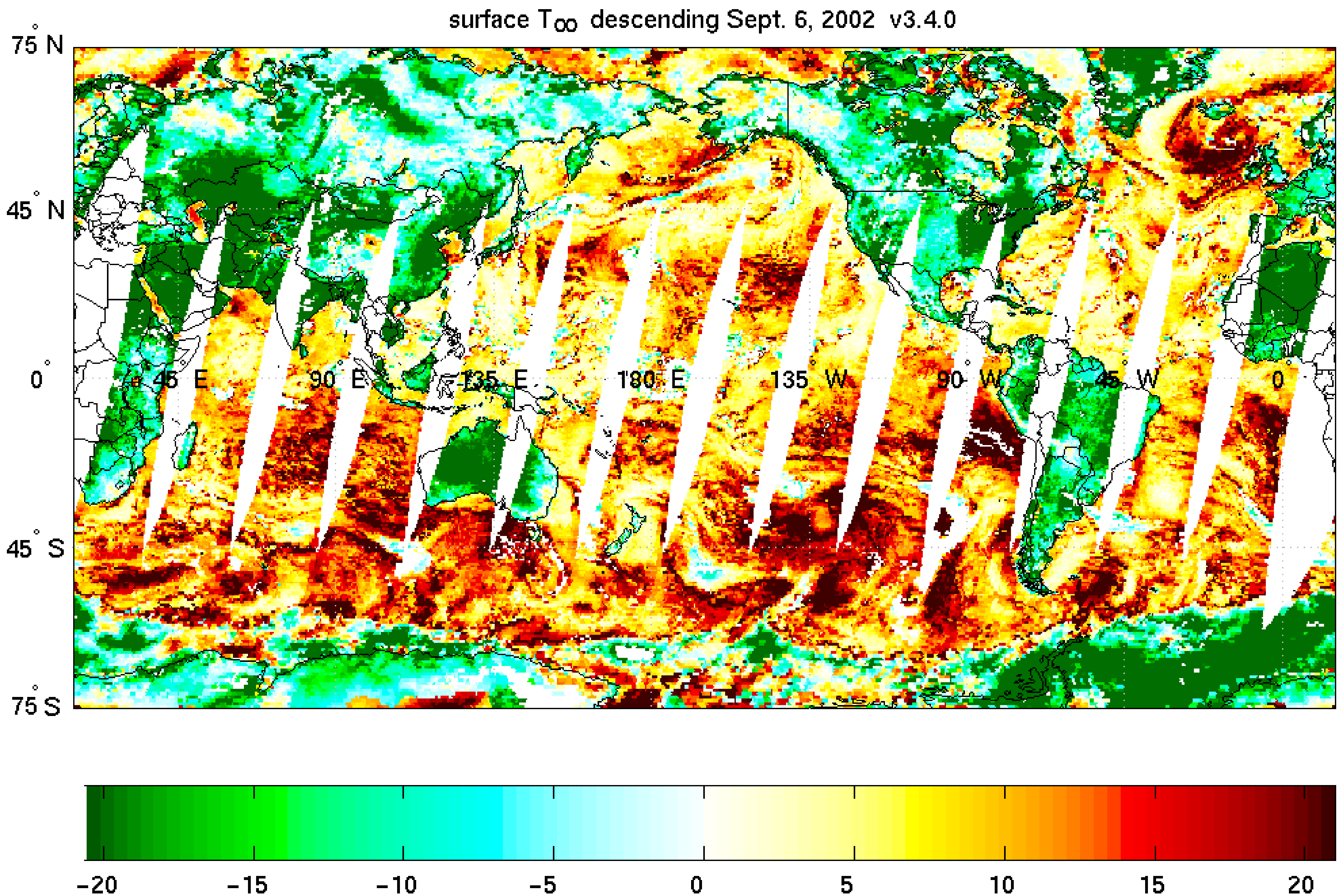
Revisions to the microwave forward model for the ocean surface were described in the December 16 and January 22 net meetings. The new seawater dielectric constant model was first included in version 3.3.1 of the Level-2 PGE, then the new downward sky-brightness model for ocean (estimation of reflected-path ratio ρ) was introduced with version 3.4.0. The latter is compared here with version 3.2.1 which preceeded the recent forward-model changes.

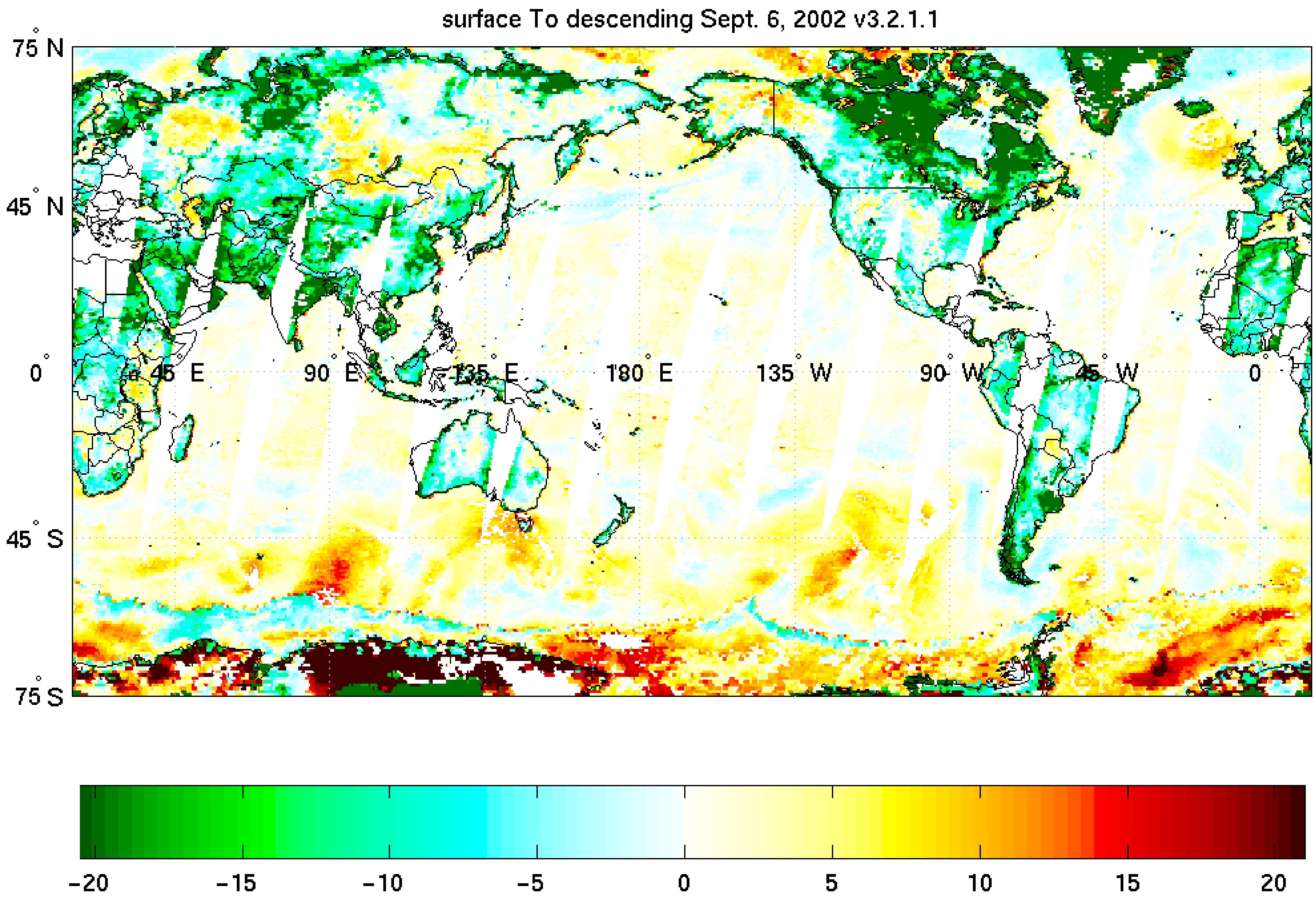
The parameters T_o , T_∞ and ρ define perturbations from a calm sea surface. The following images are for focus day 3. In the South Atlantic east of Uruguay, there is a circular spot of low wind speed (2-3 m/s) that was used as a test case in the January 22 net meeting. In the older version, T_o is close to zero there, while T_∞ is a few degrees negative. In the new version, T_o and T_∞ are both close to zero, and ρ is close to unity in this spot (-0.2, -1.2 and 1.02 respectively). Outside of heavy-cloud areas, the minimum values over ocean are close to these null values, which implies that the projection of tuning errors into the subspace of these parameters is small in v3.4.0. (Land values are not meaningful in this way.) This provides a sanity check on the tuning of window channels.

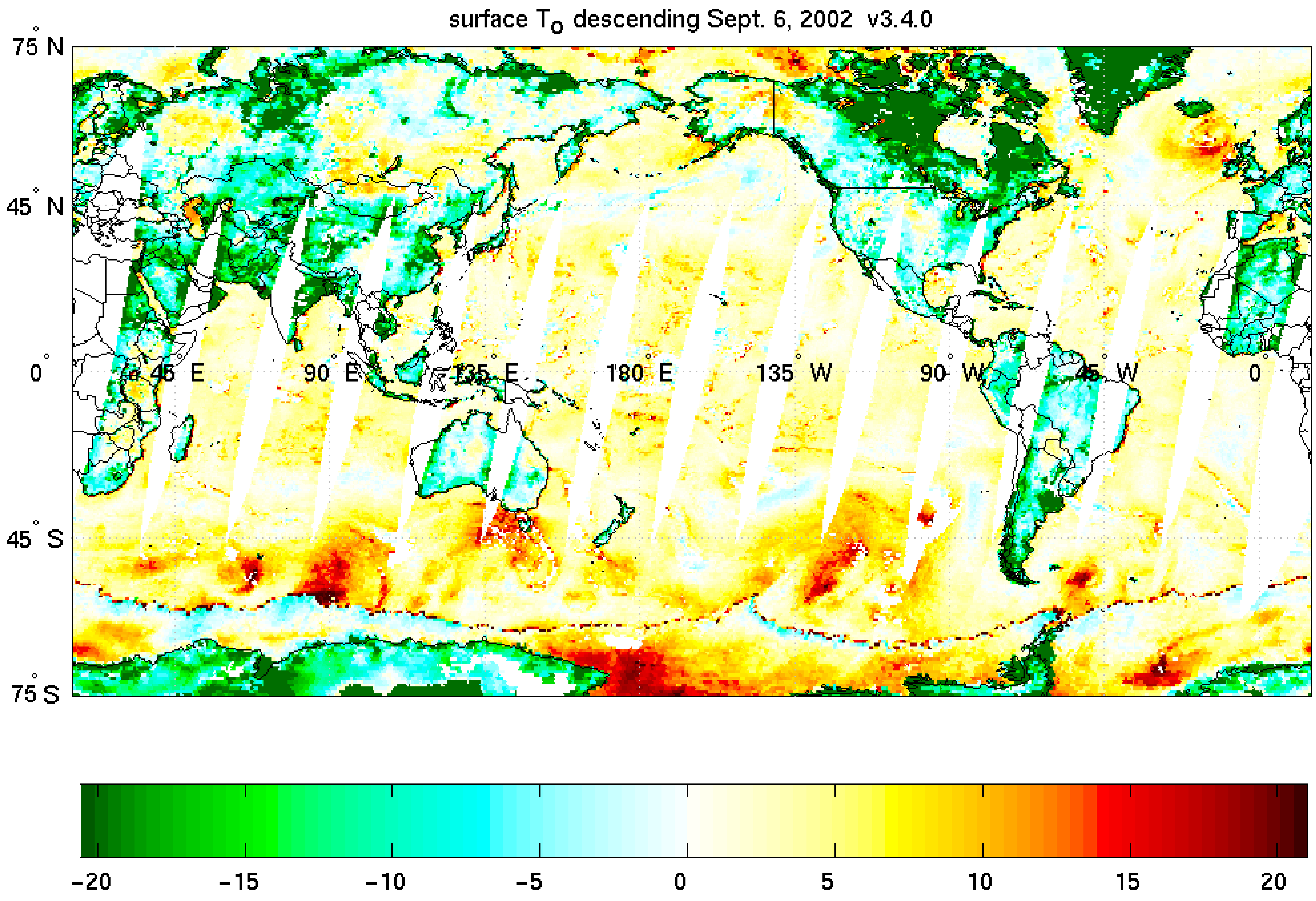
The effect of sea state should be to increase the three parameters. High values in the ocean around Antarctica correspond to regions of prevalent high wind. For the most part, T_∞ increases faster than T_o, but that is not universally true, e.g. the ocean area southwest of Australia. The sensitivity to sea state is greater in v3.4.0, due to an increase in the *a priori* variances of T_o and T_∞ (to 5^2 and 10^2 respectively).

{T_o and T_∞ are asymptotic low and high-frequency limits of the ocean-surface brightness correction.
At 50 GHz, $\Delta\,\Theta_s = (T_o + T_\infty)/2$; at 90 GHz $\Delta\,\Theta_s = 0.3\,T_o + 0.7\,T_\infty$, etc.}

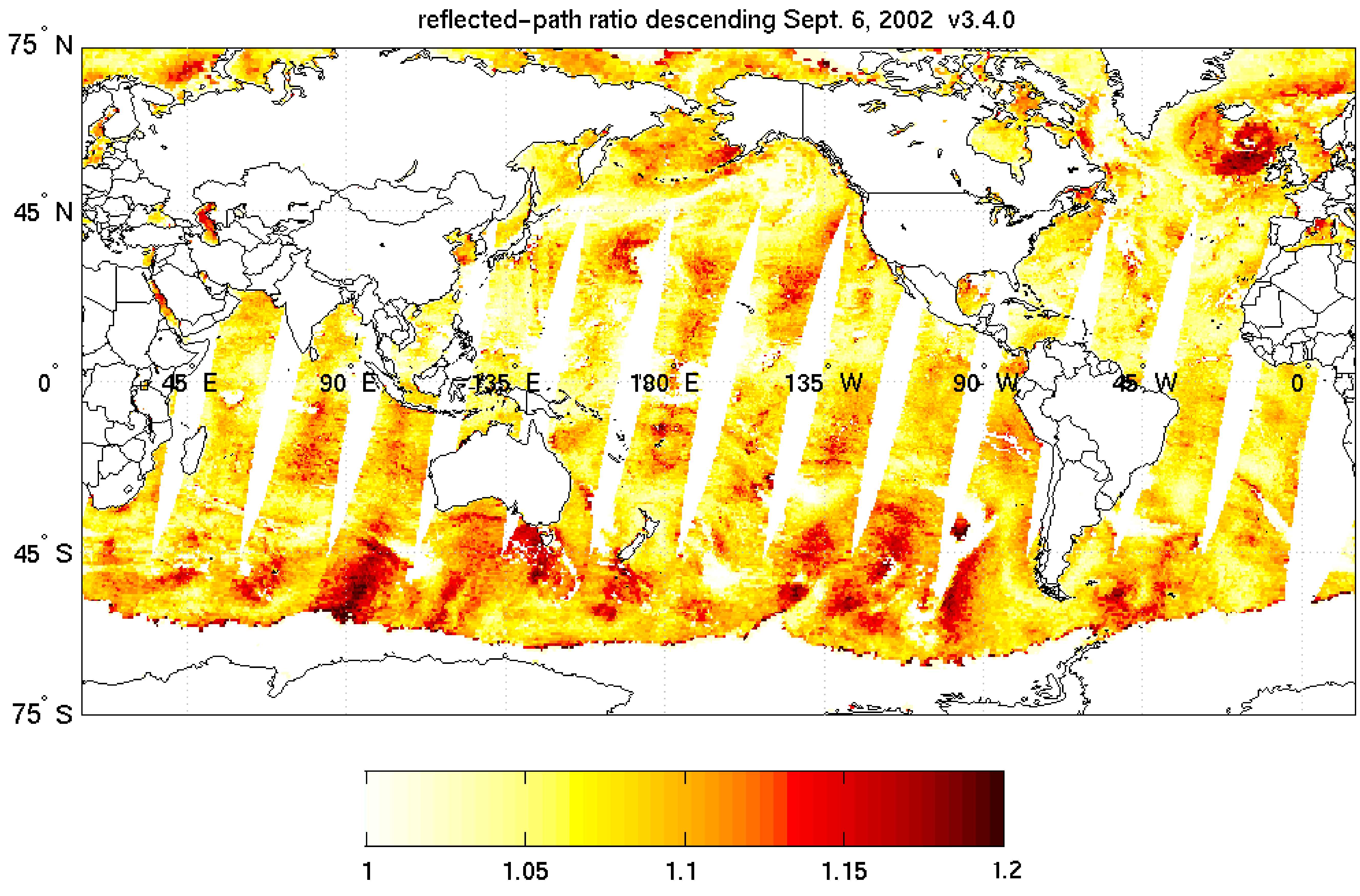

surface Too descending Sept. 6, 2002 v3.2.1.1
75° N
45° N
0°
45° S
75° S
45° E
90° E
135° E
180° E
135° W
90° W
45° W
0
low
wind
-20
-15
-10
-5
0
5
10
15
20


surface T∞ descending Sept. 6, 2002 v3.4.0
75° N
45° N
0°
45° S
75° S
45° E
90° E
135° E
180° E
135° W
90° W
45° W
0
−20
−15
−10
−5
0
5
10
15
20


surface To descending Sept. 6, 2002 v3.2.1.1
75° N
45° N
0°
45° S
75 S
45 E
90 E
135 E
180 E
135 W
90 W
45 W
0
−20
−15
−10
−5
0
5
10
15
20



surface T_O descending Sept. 6, 2002 v3.4.0
75° N
45° N
0°
45° S
75 S
45 E
90 E
135 E
180 E
135 W
90 W
45 W
0
−20
−15
−10
−5
0
5
10
15
20

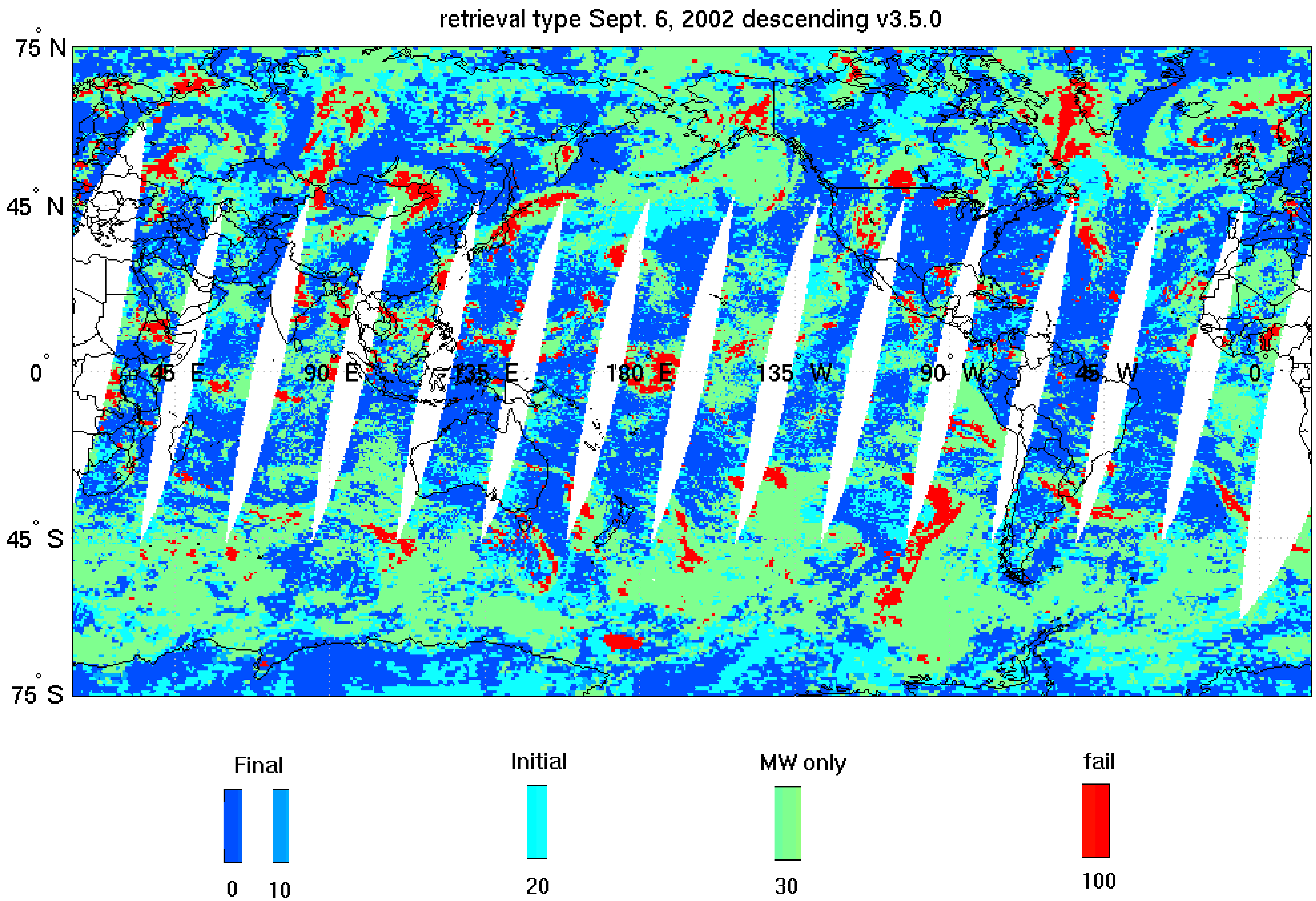

reflected-path ratio descending Sept. 6, 2002 v3.4.0
75° N
45° N
0°
45° S
75° S
45 E
90 E
135 E
180 E
135 W
90 W
45 W
0
1
1.05
1.1
1.15
1.2

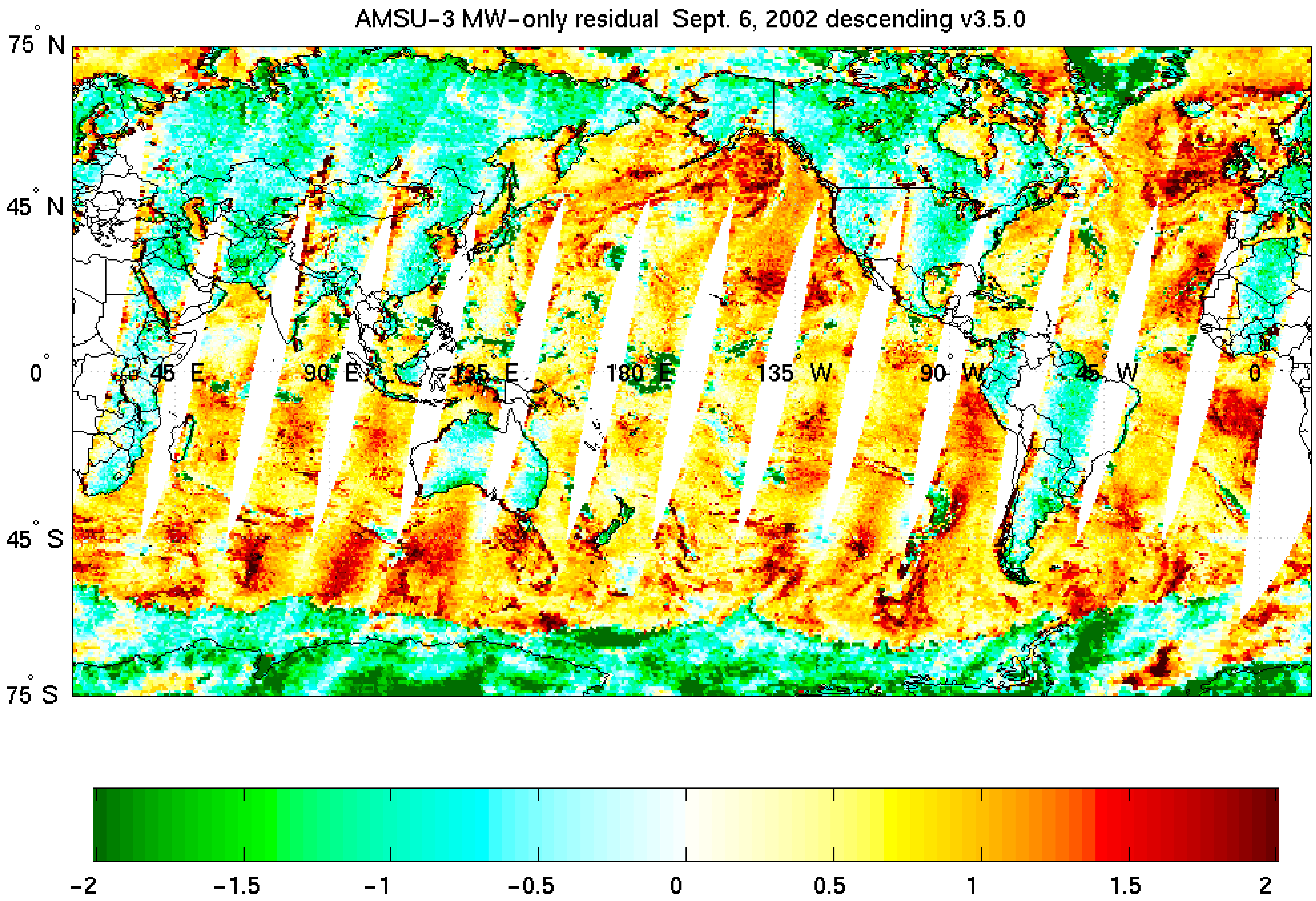
Comparison of Residuals from Microwave-only and Final Retrievals

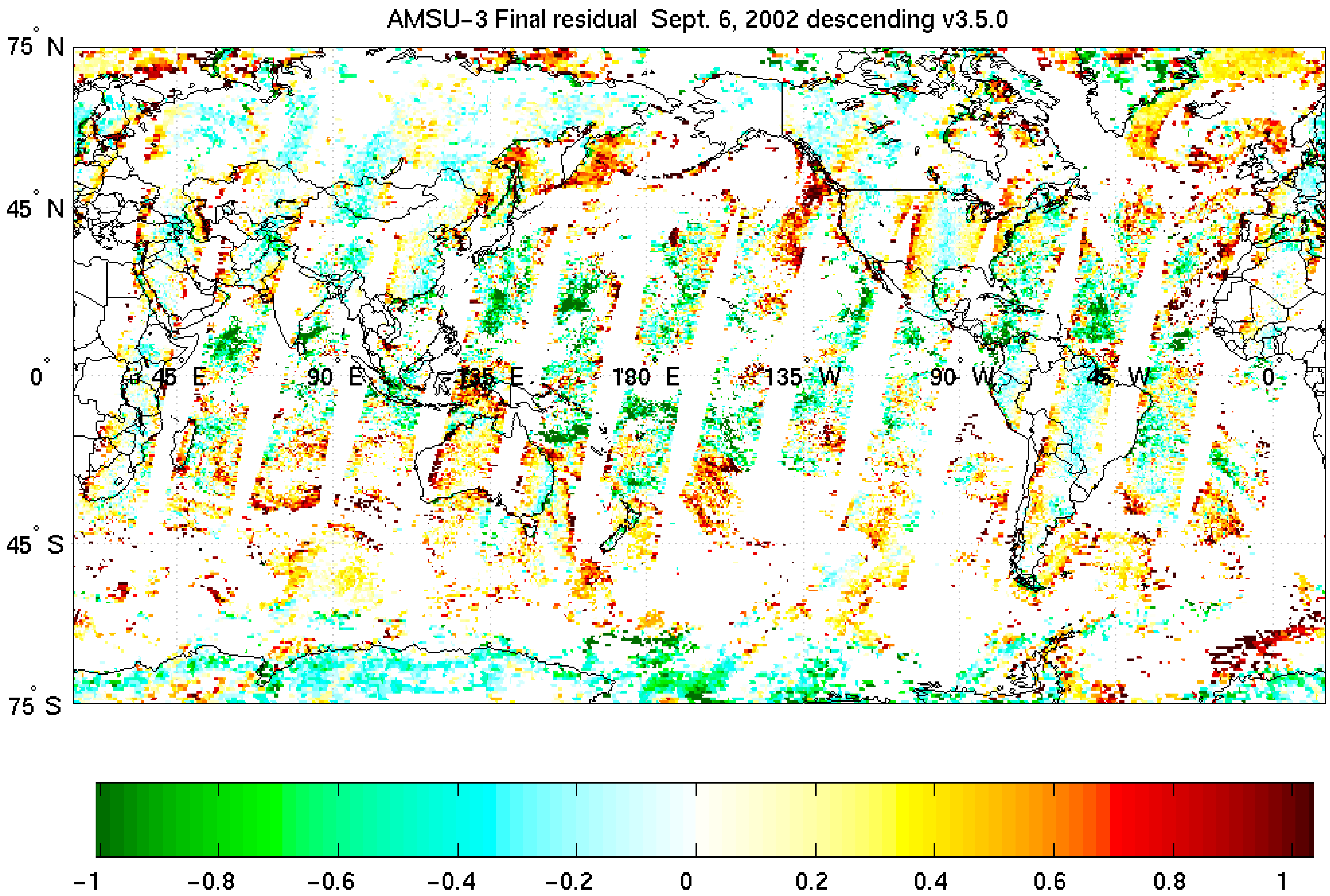
The next image displays the retrieval type of the standard output; the blue areas show where the final retrieval succeeded. Residuals for the AMSU channels are computed in both the microwave and the final retrieval stages. However, residuals are produced by the final retrieval only when successful. Residuals from the microwave-only retrieval are displayed everywhere, even where the retrieval is rejected.

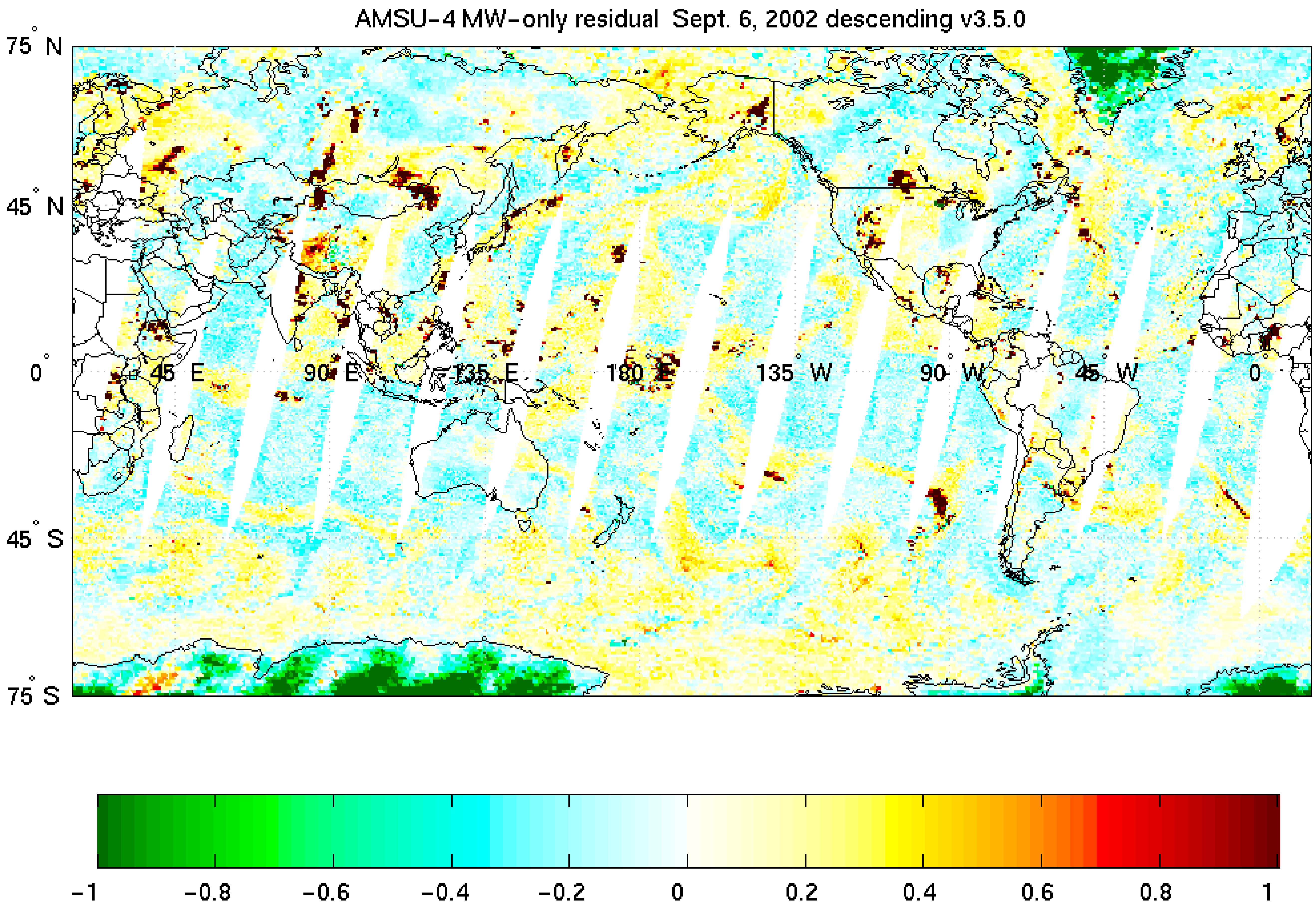
The next 6 images compare residuals on AMSU channels 3, 4, and 5 between the microwave and final stages. The final retrieval reduced residuals on ch. 3, but over land the residuals for ch. 4 are higher than from the microwave stage; this suggests that the treatment of surface emissivity needs to be re-examined to improve consistency between the final and microwave stages. Ch. 5 (less sensitive to emissivity than ch. 4) is slightly better over ocean, but slightly worse in a few places over land and ice surfaces.

The following three images show final residuals for channels higher in the atmosphere. Ch. 8 shows some consistent latitudinal variation, but ch. 9 residuals (also ch. 10-13, not shown) are very small everywhere. Ch. 14 is biased consistently high, indicating an inconsistency between microwave and infrared tuning.

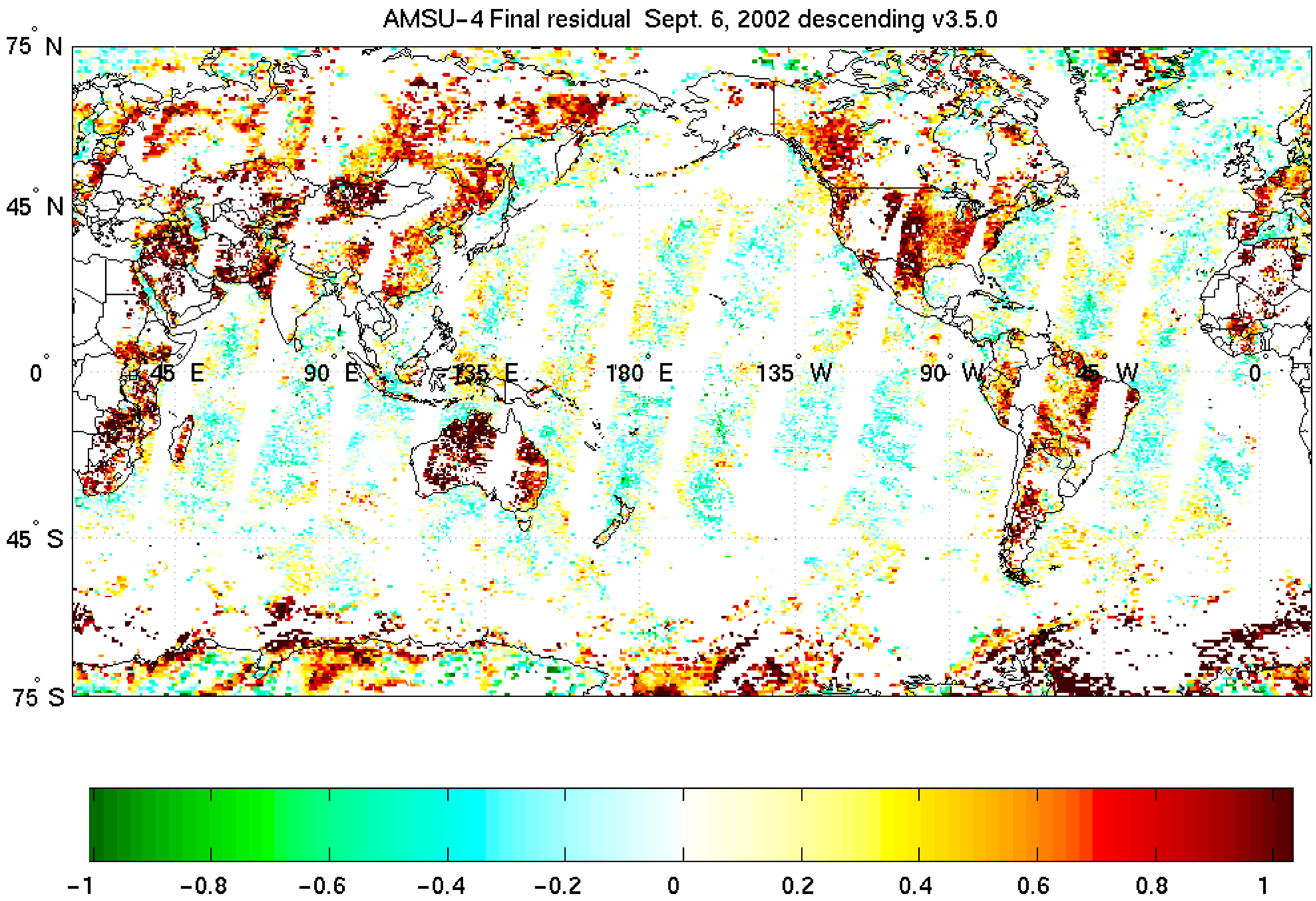

retrieval type Sept. 6, 2002 descending v3.5.0
75° N
45° N
0°
45° S
75° S
45 E
90 E
135 E
180 E
135 W
90 W
45 W
0
Final
Initial
MW only
fail
0
10
20
30
100

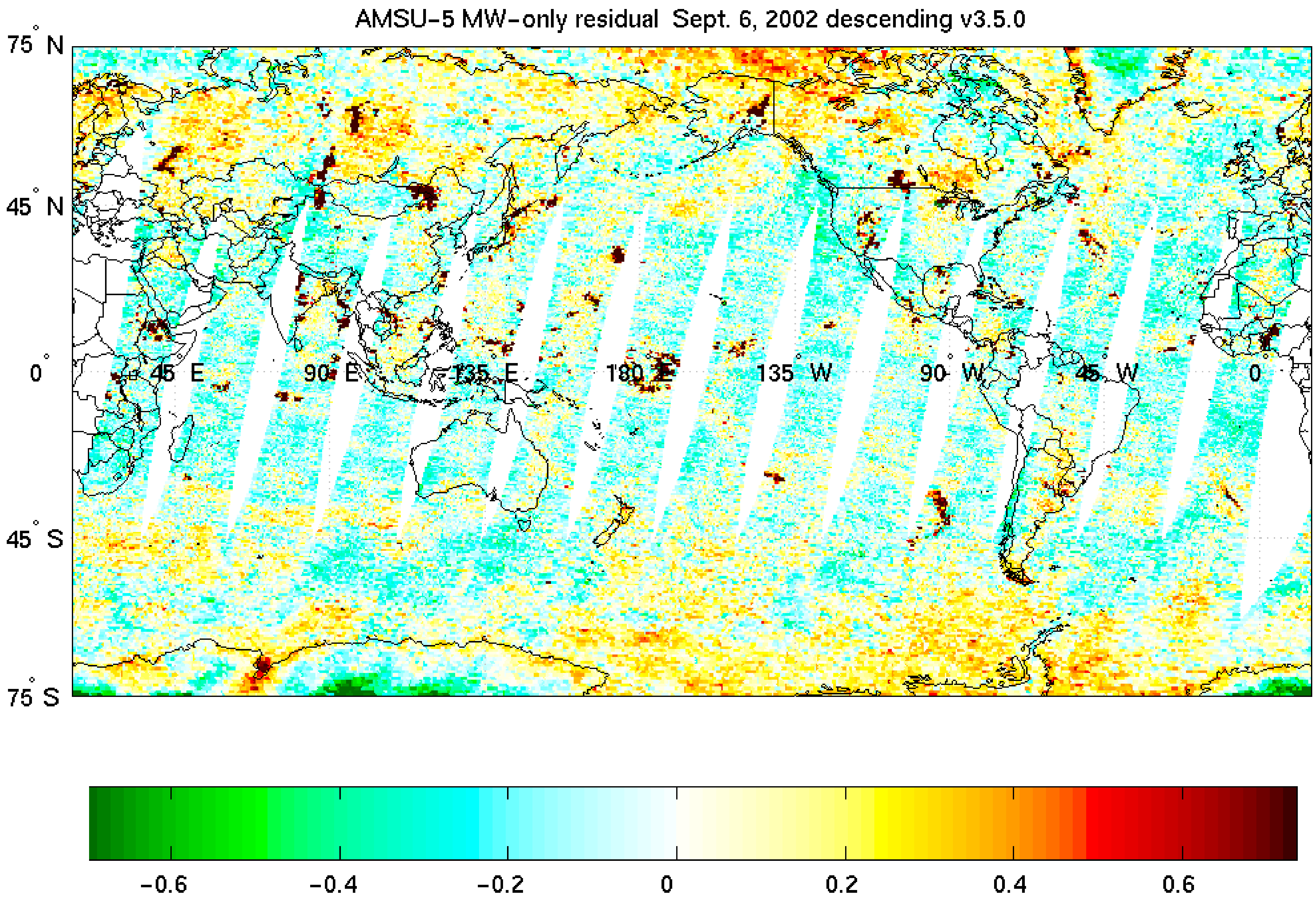

AMSU-3 MW-only residual Sept. 6, 2002 descending v3.5.0
75° N
45° N
0°
45° S
75° S
45° E
90° E
135° E
180° E
135° W
90° W
45° W
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2

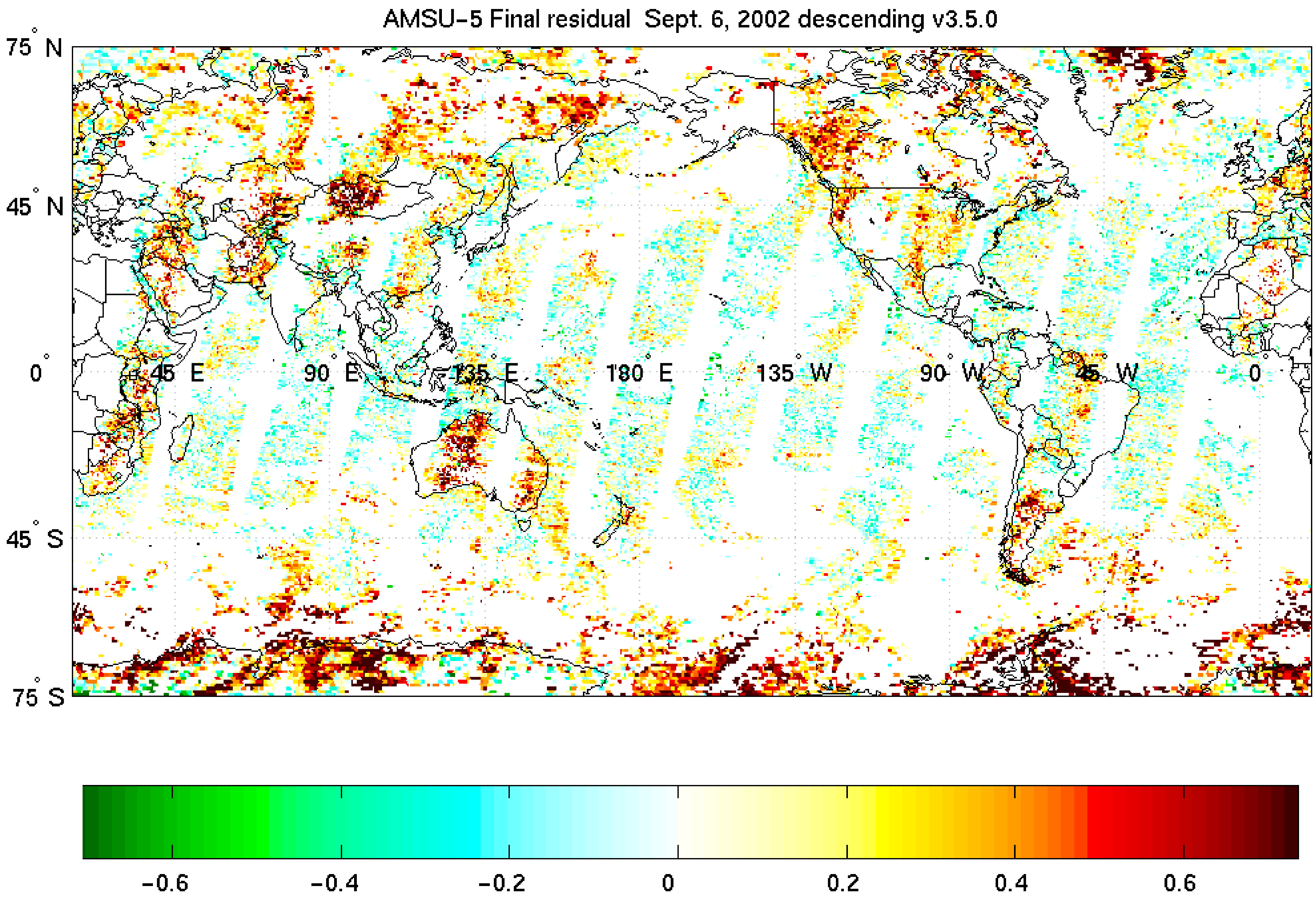

AMSU-3 Final residual Sept. 6, 2002 descending v3.5.0
75° N
45° N
0°
45° S
75° S
45 E
90 E
135 E
180 E
135 W
90 W
45 W
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1



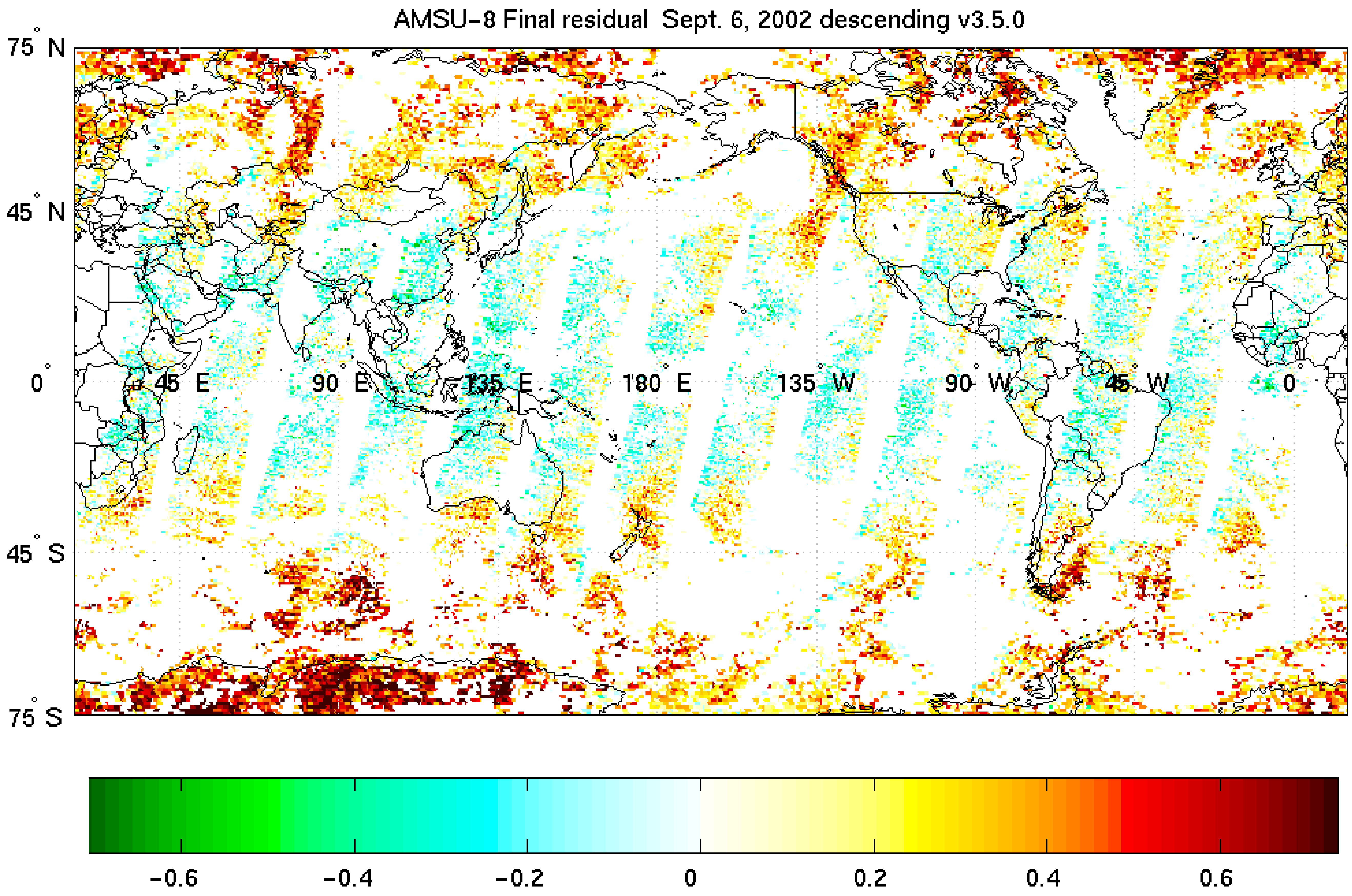
AMSU-4 MW-only residual Sept. 6, 2002 descending v3.5.0
75° N
45° N
0°
45° S
75° S
45 E
90 E
135 E
180 E
135 W
90 W
45 W
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

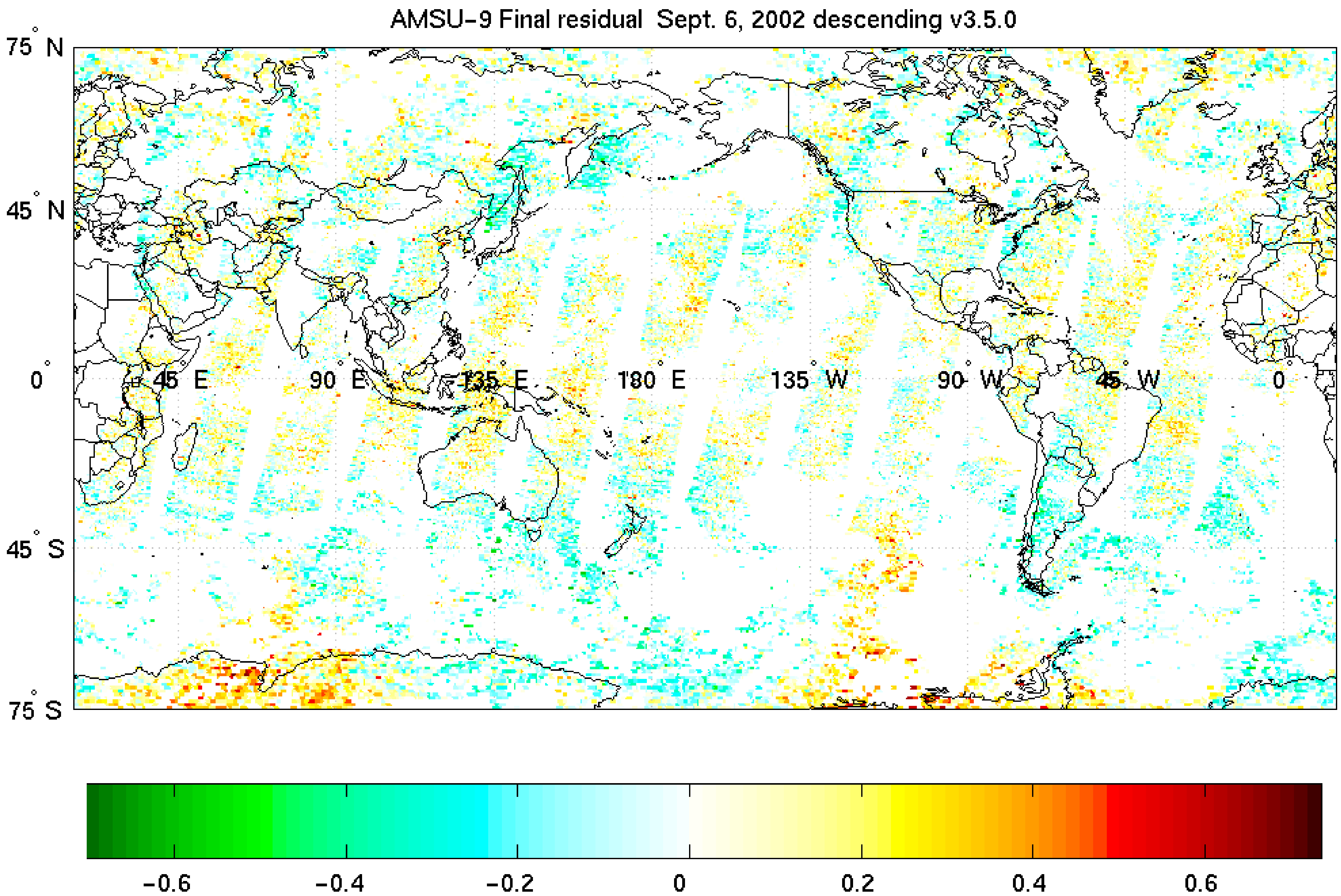

AMSU-4 Final residual Sept. 6, 2002 descending v3.5.0
75° N
45° N
0°
45° S
75° S
45 E
90 E
135 E
180 E
135 W
90 W
45 W
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

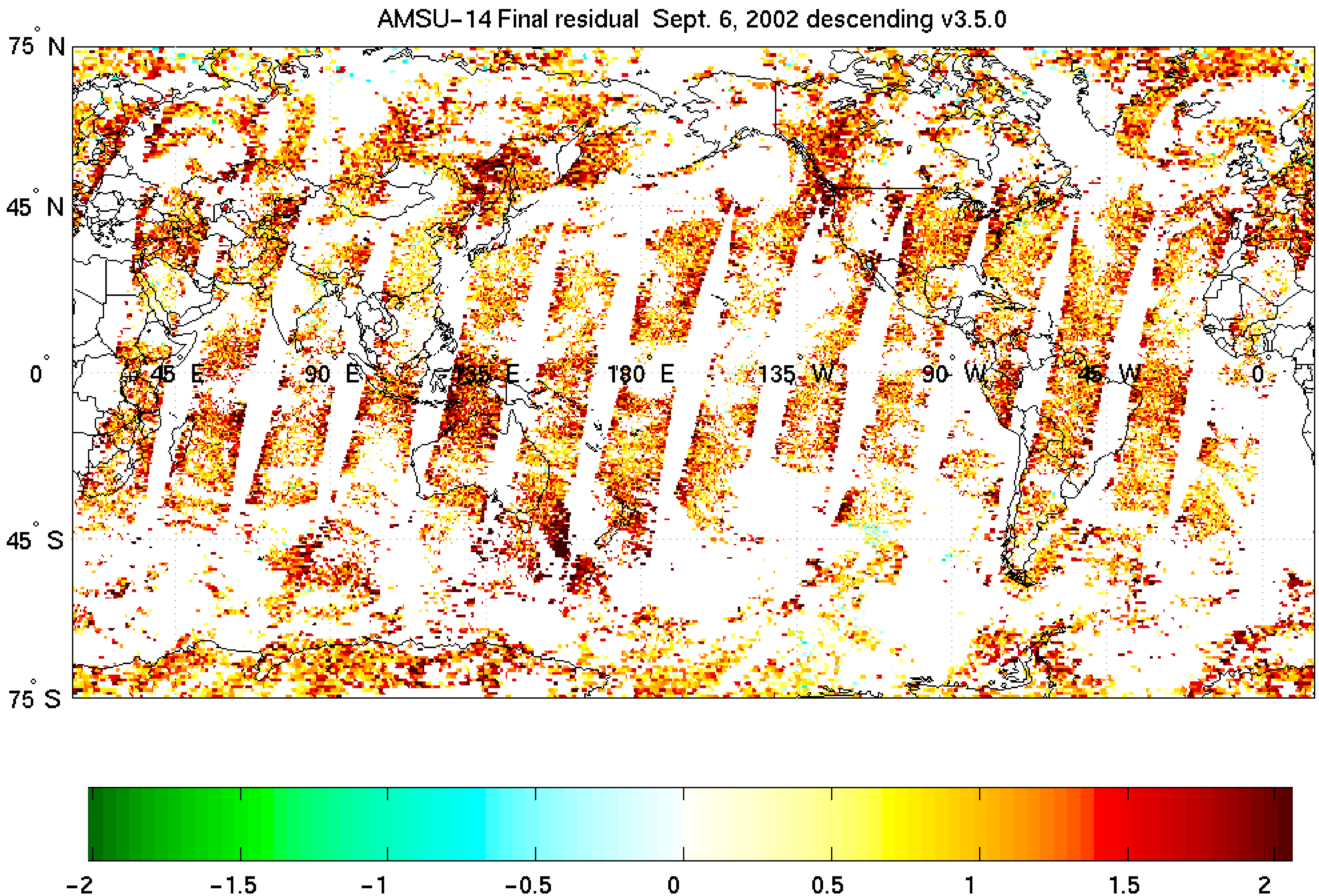

AMSU-5 MW-only residual Sept. 6, 2002 descending v3.5.0
75° N
45° N
0°
45° S
75° S
45 E
90 E
135 E
180 E
135 W
90 W
45 W
0
-0.6
-0.4
-0.2
0
0.2
0.4
0.6



AMSU-5 Final residual Sept. 6, 2002 descending v3.5.0
75° N
45° N
0°
45° S
75° S
45 E
90 E
135 E
180 E
135 W
90 W
45 W
0
-0.6
-0.4
-0.2
0
0.2
0.4
0.6


AMSU-8 Final residual Sept. 6, 2002 descending v3.5.0
75° N
45° N
0°
45° S
75° S
45 E
90 E
135 E
180 E
135 W
90 W
45 W
0
−0.6
−0.4
−0.2
0
0.2
0.4
0.6

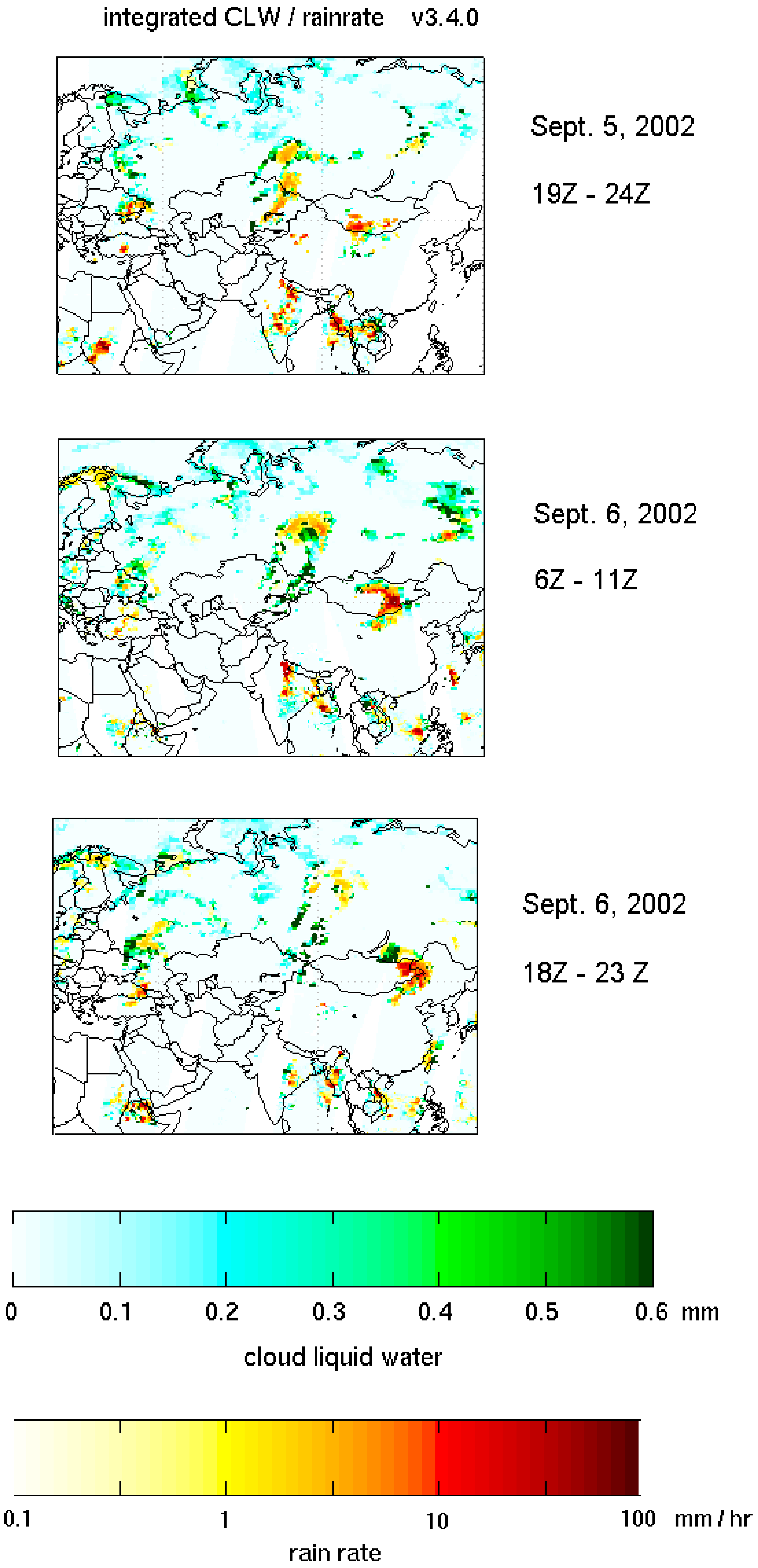

AMSU-9 Final residual Sept. 6, 2002 descending v3.5.0
75° N
45° N
0°
45° S
75° S
45 E
90 E
135 E
180 E
135 W
90 W
45 W
0
-0.6
-0.4
-0.2
0
0.2
0.4
0.6


AMSU-14 Final residual Sept. 6, 2002 descending v3.5.0
75° N
45° N
0°
45° S
75° S
45 E
90 E
135 E
180 E
135 W
90 W
45 W
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2

Weather-Front Sequence   Sept. 5-6, 2002

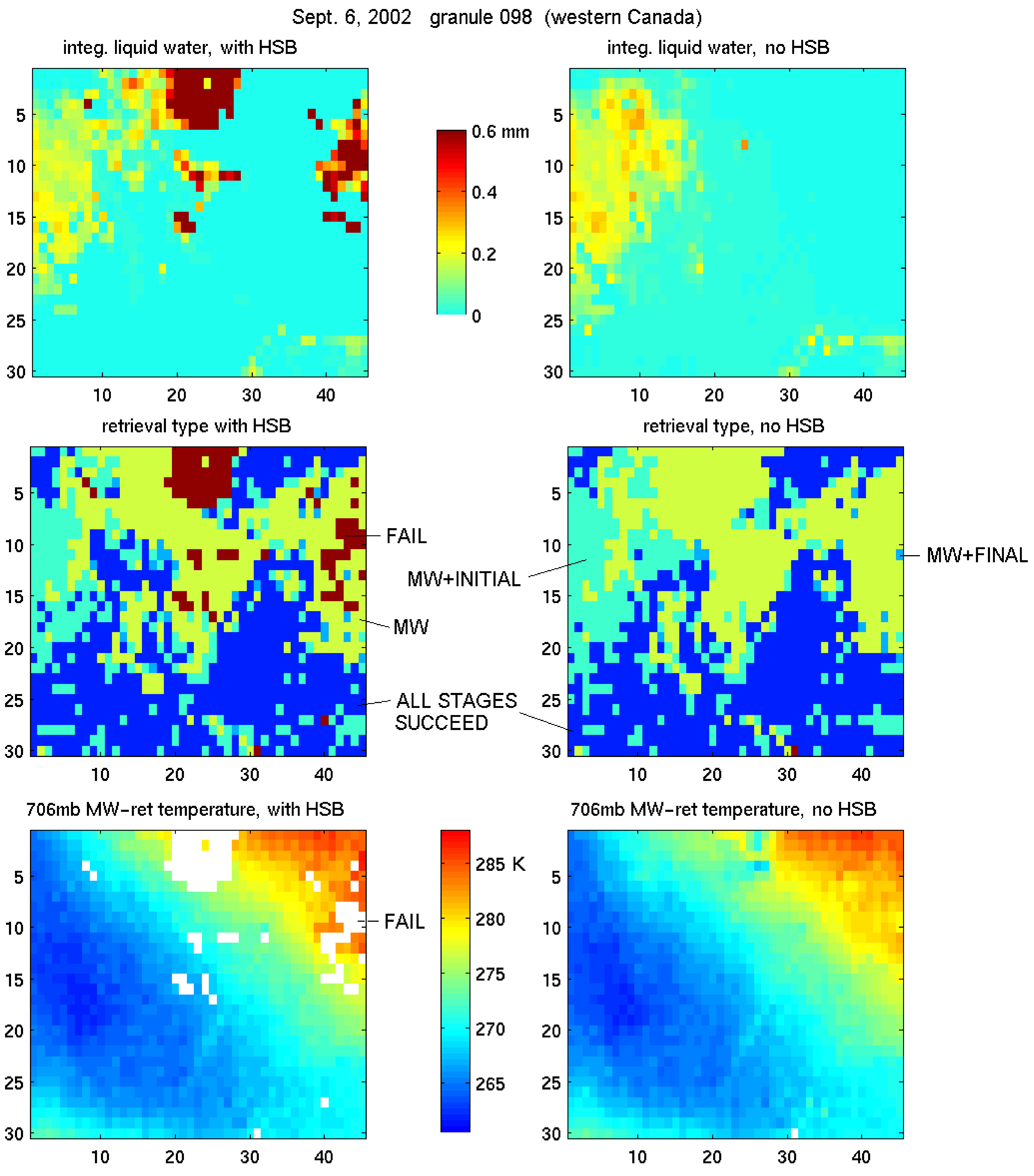
The next page shows a sequence of images combining the integral of the retrieved liquid-water profile with the rain-rate estimate (v.3.4.0), over asia. In central Siberia, a frontal system is seen moving northeastward. A second front over Mongolia moves in a more nearly eastward direction. In both cases, the early stages are characterized by a predominance of yellow and red colors, which denote rain found by the precipitation algorithm, while in the later stages they are accompanied by dark green pixels. The latter denote relatively high values of cloud liquid, which may actually be precipitating. If this interpretation is correct, these pixels are not detected by the precipitation algorithm due to lack of high-altitude glaciation.

{The current L2 PGE rejects retrievals with integrated liquid exceeding 0.5 mm, but they are plotted here as long as the retrieval passes the residual test.}


integrated CLW / rainrate v3.4.0
Sept. 5, 2002
19Z - 24Z
Sept. 6, 2002
6Z - 11Z
Sept. 6, 2002
18Z - 23 Z
0
0.1
0.2
0.3
0.4
0.5
0.6 mm
cloud liquid water
0.1
1
10
100 mm / hr
rain rate

Comparison of Retrievals with and without HSB

Granule 098, Sept. 6, 2002 was run without using HSB for comparison to the v.3.5.0 retrieval with HSB. This granule is over western Canada, with two areas of rain along the top and right side of the images as displayed. Using HSB data, the raining footprints are rejected beause of high amounts of liquid water and/or failure to satisfy the residual tests. Without HSB, these footprints are passed as accepted microwave retrievals (yellow, type 30) although the temperature field shows perturbations from the rain. Around footprint (12,12) there is an area in which the retrieval without HSB overestimates the cloud liquid; this leads to a rejection in the final retrieval stage, but not earlier.


Sept. 6, 2002 granule 098 (western Canada)
integ. liquid water, with HSB
integ. liquid water, no HSB
0.6 mm
0.4
0.2
0
retrieval type with HSB
retrieval type, no HSB
FAIL
MW+INITIAL
MW+FINAL
MW
ALL STAGES
SUCCEED
706mb MW-ret temperature, with HSB
706mb MW-ret temperature, no HSB
285 K
280
275
270
265
FAIL

Conclusions

1. The projection of tuning errors into the T_o , T_∞ , ρ subspace is small in v.3.5.0.

2. Modeling of microwave emissivity is not entirely consistent between the microwave and final retrievals.

3. Tuning of ch. 14 is not consistent with similar infrared channels.

3. The liquid water product may respond to warm rain, although at present it is not calibrated for that condition.

3. HSB failure degrades the microwave quality control.

Future Work

1. Incorporate an ocean-surface roughness model that is consistent with the retrieval into the stand-alone microwave forward model (m_rta).

2. Investigate possible extension of the microwave forward model to warm rain (i.e., large droplets).

3. Consistency between microwave and final retrieval stages: (a) MW-emissivity estimation in final retrieval; (b) Potential improvements (with or without HSB) from use of IR cloud-top pressure as a constraint in the retrieval of liquid water.